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Amended claims in accordance with Rule 137(2) EPC.

(54) **A cooling arrangement for a gas turbine**

(57) A gas turbine comprises an inner casing (3) and a rotor (1) having rotating blades (5) with a shroud (7) and a fin (8), and a cooling arrangement arranged in a cavity (9) in the casing (3) and about the rotating blade (5). According to the invention, the blade shroud (7) comprises a protrusion (12) extending away from the blade leading edge (te₅) into the cavity (9) and openings (11') in the cavity wall (9a) for a cooling fluid. The protrusion

(12) is defined by angles in relation to the flow channel wall (4'). The protrusion (12) effects a vortex flow of cooling fluid entering through the openings (11') and a vortex flow of hot gas entering from the flow channel (4) into the cavity (9). The double-vortex formation reduces a mixing of the cooling flow with the hot gas flow and increases the efficiency of the cooling arrangement of the blade shroud and cavity walls.

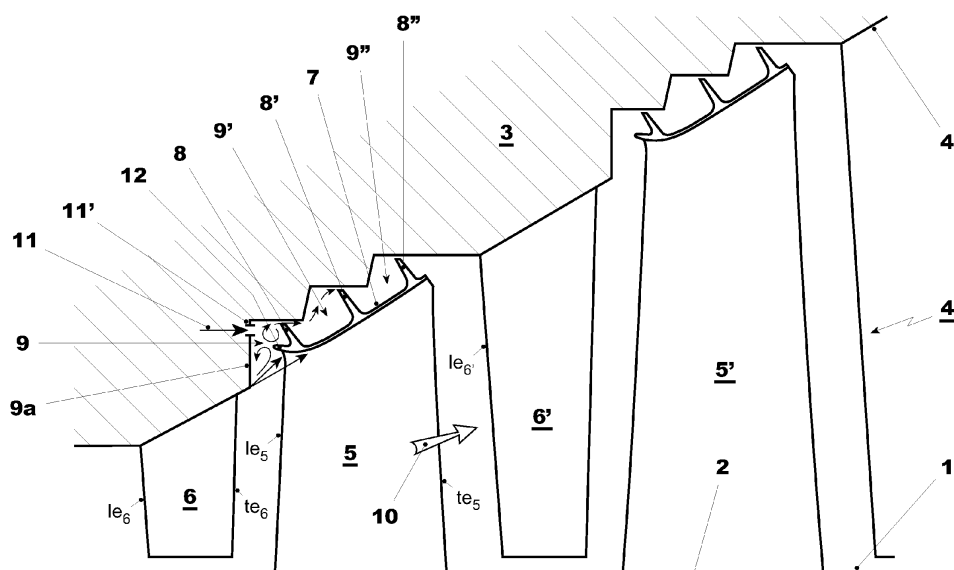


FIG. 1

Description

Technical Field

[0001] The present invention pertains to a gas turbine with shrouded rotating blades and in particular a cooling arrangement for the cooling of the blade shrouds.

Background Art

[0002] Gas turbine rotating blades of the first blade rows of a gas turbine are typically designed with a blade shroud at their tips extending circumferentially along the blade row. The blade shroud is intended to limit the amount of working fluid flow leaking through a clearing gap between the blade tips and the flow channel wall and thereby maximizing the effect of the working fluid on the rotating blades. Especially in the first stages of a gas turbine, where the temperatures of the turbine gases are at their highest, the rotating blades are fully shrouded. The blade shrouds form a continuous ring encompassing the blade tips and the entire circumference of the blade row thereby minimizing the hot gas flow reaching the flow channel walls. A blade shroud often includes one or more fins, also known as knife-edges, that extend radially or partially radially away from the shroud and towards the gas turbine stator and flow channel wall.

[0003] The stator or inner casing of the turbine forming the flow channel wall includes the carriers for the vanes as well as thermal heat shields mounted on its inner walls.

[0004] The heat shields protect the wall of the flow channel, or gas turbine inner casing, from the high-temperature gas flow driving the gas turbine and thereby assure an economical operating lifetime.

[0005] The blade shrouds and flow channel wall with heat shields are furthermore often actively cooled by means of cooling flows directed to the shroud and heat shields. EP 1 219 788 for example, discloses a gas turbine with blade shrouds and heat shields that are cooled by means of a cooling airflow passing through a cooling channel extending through the inner casing and heat shield and leading to a space between two fins of the blade shroud and the heat shield. From that space, the cooling flow passes over the shroud and the fins to both the leading and trailing edges of the blade shroud, where it enters into the hot gas flow of the turbine. The cooling air requires an appropriate pressure level for the cooling flow to reach the leading edge of the shroud by flowing in a direction opposite the direction of the hot gas flow.

[0006] EP 2009248 discloses a gas turbine and a cooling arrangement for the cooling of the rotating blade tips including a cooling flow passage directing a cooling flow to the leading edge of the blade shroud. A leakage flow from the gas turbine flow channel is allowed to reach the exit opening for the cooling passage and mix with the cooling flow emerging from the passage.

Summary of Invention

[0007] It is an object of the invention to provide a gas turbine having rotating blades with blade shrouds and a gas turbine stator having heat shields and vane carriers and in particular a cooling arrangement for the rotating blade shroud by means of a cooling airflow entering through a heat shield in the stator that is improved over cooling arrangements for such gas turbines known in the prior art.

[0008] A gas turbine comprises a rotor rotatable about a rotor axis, a stator or gas turbine inner casing, rotating blades mounted on the rotor in circumferential rows and stationary blades or vanes mounted in circumferential rows on the stator or inner casing, the rotating blades each having a leading and a trailing edge and extending radially outward from a blade root to a blade tip. The inner wall of the inner casing and the rotor surface define a gas turbine flow channel for the hot turbine gases to flow and drive the turbine. The wall of the inner casing comprises vane carriers and thermal heat shields that protect it from the hot gases. Furthermore the stator or inner casing wall comprises a contour forming circumferentially extending cavities radially opposite the rotating blade tips or about the rotating blade leading and trailing edge or both and into which the rotating blade shroud extends. Each rotating blade of the gas turbine comprises a blade shroud on its tip having at least one fin, which extends from the shroud towards a circumferential cavity in the stator or inner casing wall. The gas turbine furthermore comprises a cooling arrangement with openings for a cooling flow arranged in the wall of a circumferentially extending cavity in the inner casing.

[0009] According to the invention, the cooling arrangement comprises a protrusion on the leading edge of the shroud of the gas turbine blade extending away from the leading edge of the blade and into the circumferential cavity in the inner casing wall having the openings for the cooling flow. In particular, the protrusion extends in a direction dividing the space of the circumferential cavity into a first, radially outer space and a second, radially inner space, where the openings for the cooling flow are arranged within the radially outer space.

[0010] The protrusion on the blade shroud effects a division of the circumferential cavity space between the fin and the inner casing wall into two spaces, where openings in the wall of the circumferential cavity in the inner casing are configured and arranged to allow the cooling fluid flow to enter the radially outer space of said cavity radially outward from the protrusion on the blade shroud. This effects that the cooling fluid flow entering the cavity through the openings in the inner casing wall is separated from the hot gas flow in the turbine flow channel. The first, radially outer space is defined by the cavity wall, the fin on the shroud, and the radially outer surface of the protrusion on the shroud. The second, radially inner space is defined by the radially inner surface of the protrusion and the cavity wall. The division of the cavity

space allows the cooling flow entering the cavity to remain within the first, radially outer space and to follow a vortex path therein, thereby effecting an improved cooling of the shroud and the heat shields on the inner casing. The cooling flow within that first space can continue to flow through a clearing gap between the fin and the radially opposite inner casing wall to further portions of the rotating blade shroud in the downstream.

[0011] The protrusion on the shroud leading edge furthermore significantly reduces and minimizes the mixing of the hot gas flow with the cooling flow in the radially outer space. The protrusion on the shroud furthermore effects that the hot gas flow reaching into the radially inner space of the cavity is largely contained within the radially inner space and limits its entry into the outer space. Instead, the protrusion forces the hot gas flow into a vortex path within the radially inner space, which further limits its flow through a clearing gap between the protrusion and the cavity wall and into the radially outer space of the cavity. The hot gas flow and the cooling flow, each forced into a vortex, therefore remain substantially contained such that mixing of the two flows is limited and the temperature of the cooling flow is kept at a lower level. The cooling effectiveness of the cooling arrangement is thereby further improved. By improved cooling efficiency the operating lifetime of the blade can be extended. In addition, less cooling fluid is necessary, which improves the efficiency of the gas turbine.

[0012] In an exemplary and particular embodiment of the invention, the radially inner surface of the protrusion on the shroud extends toward the cavity wall at an angle with respect to the direction of the flow channel wall at the inner casing, where this angle is within a range from 30° to 60° . This division of the cavity into the two spaces allows an optimization of the radially outer space for the cooling flow and of the effective cooling of the shroud and heat shields

[0013] In a further exemplary and particular embodiment of the invention, the degree that the protrusion on the blade shroud extends into the space of the circumferential cavity is defined by an angle, where this angle is defined by the direction of the flow channel wall and a line of sight from the tip of the protrusion to the radially inner most point of the wall of the circumferential cavity, where the wall of the circumferential cavity meets the trailing edge of the stationary blade adjacent upstream of the rotating blade. According to the exemplary embodiment, this angle is within a range from 10° to 40° . The angle range assures that the hot gas flow along the flow channel wall and in the direction of the blade shroud impinges on the radially inner surface of the shroud protrusion and separates into two flows at the rotating blade leading edge. Thereby, the vortex flow within the radially inner cavity space is optimally initiated.

[0014] The direction of the vortex initiated within the radially inner space is given by, starting at the leading edge of the blade, a first radially outward flow, followed by a flow in an upstream direction relative to the direction

of the gas flow in the flow channel, then by a radially inward flow, then by flow in a downstream direction, then again in the radially outward direction. This direction of the vortex flow in turn contributes to driving the vortex flow in the first, radially outer cavity space. There, the direction of the vortex flow of the cooling flow is, starting from the entry through the openings in the cavity wall, first in the downstream direction relative to the direction of the main flow in the flow channel, then radially inward, then in the upstream direction, then radially outward, and then again in downstream direction.

[0015] In a further exemplary embodiment of the invention, the protrusion extends at an angle such that it divides the cavity into two spaces each having a radial extension, where the ratio of the radial extension of the first, radially outer space to that of the second, radially inner space is at least 1:4. A line tangent to the outermost tip of the protrusion and extending towards the cavity wall meets the cavity wall of the inner casing at a point considered the point separating the radial outer space from the radial inner space of the cavity. The radial extension of the outer space from this separation point to the radial outer wall of the cavity is at least 25% of the radial extension of the radially inner space. The radial extent of the radially inner space is measured from said separation point to the point, where the cavity wall meets the flow channel wall at the stationary blade adjacent to and upstream of the rotating blade. The disclosed range of the ratio of the radial extensions of the two spaces allows on one hand sufficient space for the cooling flow to follow its vortex flow and perform an optimized cooling of the shroud and heat shields. On the other hand, it allows the hot gas flow near the flow channel wall to most effectively enter a vortex flow within the cavity and/or continue in the flow channel along the blade shroud and in the direction of the flow channel wall.

[0016] In a further exemplary embodiment of the invention, the amount the protrusion extends into the cavity of the inner casing is defined by an angle between the direction of the flow channel wall and a line extending from the outermost tip of the protrusion to the radially inner end of the cavity, where the wall of the cavity meets the flow channel wall at the stationary blade adjacent to and upstream of the rotating blade.

[0017] In a further exemplary embodiment of the invention, the openings of the cooling arrangement are arranged within a radially outermost region of the first, radially outer cavity space. Specifically, this region encompasses the radially outermost half of the first, radially outer cavity space.

Brief Description of the Drawings

[0018]

Figure 1 shows a view of a part of a gas turbine in a meridional section through the axis of the rotor of the gas turbine including the gas turbine rotor with rotat-

ing shrouded blades and the gas turbine stator arranged about the rotor with stationary blades and the turbine inner casing.

Figure 2 shows a rotating shrouded blade of the gas turbine of figure 1. It shows in particular and in greater detail, the contour of a cavity at the inner casing wall opposite the rotating blade shroud and the blade shroud including a protrusion at its leading edge according to the invention. The flow paths of the cooling flow and hot gas flow effected by the shroud protrusion are indicated.

Figure 3 shows the same partial view of a gas turbine as shown in figure 2 and in particular the dimensional details of the shroud protrusion in relation to the cavity in the inner casing wall of the gas turbine.

Best Modes for Carrying out the Invention

[0019] Figure 1 shows in a meridional section view an exemplary gas turbine according to the invention comprising a shaft 1 rotatable about a rotor axis 2 and rotating blades 5 arranged on the shaft 1 in circumferential rows by means of blade roots (not shown). The rotor 1 is enclosed by a stator comprising an inner casing 3 and stationary blades or vanes 6. The stationary blades or vanes 6 are mounted on the stator in circumferential rows by means of vane carriers, where each row is positioned adjacent a row of rotating blades 5. The blades 5, 6, 5', 6' have leading edges le_5 , le_6 , le_5' , le_6' and trailing edges te_5 , te_6 , respectively. The direction of the hot gas flow through the gas turbine is indicated by the arrow 10. The inner casing 3 is delimited by an inner casing wall 4', which forms together with the surface of the rotating shaft 1 the flow channel 4 of the gas turbine. The inner casing wall 4' extends in this sectional view from the rotor axis 2 in the flow channel direction at an angle to the rotor axis and along the contour of the inner casing at the vanes 6, 6'.

[0020] The inner casing wall 4' is protected from the hot gas temperatures by thermal heat shielding elements, which are not individually illustrated in detail in these figures. The contour of the channel wall 4' shown may be understood as an exemplary contour of the channel wall including the thermal shielding elements.

[0021] In this disclosure, a radially outward direction is defined as the direction radially away from the rotor axis 2, while a radially inward direction is defined as the direction radially toward the rotor axis 2. An axial direction is defined by a direction parallel to the rotor axis 2. An upstream direction is defined as the direction opposite the hot gas flow 10, while a downstream direction is defined as the direction of the hot gas flow 10 itself.

[0022] Each rotating blade 5 of a blade row comprises at its tip or radially outer end a shroud 7 having one or more fins 8, 8', 8". The fins extend from the shroud 7 toward the inner casing wall 4'. The contour of the inner

casing wall 4' at this location forms circumferential cavities 9, 9', 9", into which extend the fins 8, 8', 8" respectively. The fins limit together with the wall cavities the leakage flows through the clearing gaps between the rotating blades and the inner casing and thereby increase the power of the turbine. The cavity 9 radially opposite and upstream of the leading edge le_5 of the rotating blade 5 is delimited by a first wall 9a extending radially outward from the trailing edge te_6 of the stationary blade 6 and a second wall 9b extending in an axial direction. The first fin 8 of the shroud 7 extends into this cavity 9. The cavity walls 9a and 9b form together with the fin 8 the cavity space 9, into which can flow a portion of the hot gas 10 from the flow channel 4. In order to prevent excessive temperatures of the cavity walls and of the shroud 7 in the vicinity of the cavity, the heat shielding elements at the cavity walls comprise openings 11' for a cooling flow 10 to enter and cool the shroud and cavity walls.

[0023] According to the invention, the shroud 7 comprises at its leading edge a protrusion 12 having in its cross-section an elongated shape extending away from the leading edge le_5 of the rotating blade 5 toward the radially extending wall 9a of the cavity 9. The protrusion 12 effects a spatial division of the cavity 9 into two spaces, a first, radially outer space between the axially extending cavity wall 9b and the protrusion 12 and a second, radially inner space between the protrusion 12 and the cavity wall 9a extending to the point, where the cavity wall 9a meets the trailing edge te_6 of the stationary blade 6 adjacent to the rotating blade 5.

Figure 1 shows an exemplary gas turbine according to the invention. However, the invention encompasses gas turbines with this kind of shape of cavities in the inner casing wall as well as further shapes. Further examples of the invention include gas turbines with inner casing walls having cavities opposite from the rotating blade row, where the cavity walls can have slightly different but essentially similar shapes. Specifically, the cavity walls extending axially can extend exactly axially, however they can also extend partially or substantially axially, but in any case away from the direction of the flow channel wall 4'. They can also be understood as having a curved shape. Respectively, the walls extending radially are to be understood to extend either exactly radially, but also partially or substantially radially, but in any case away from the direction of the flow channel wall 4'. Again, they can also be understood as having a curved shape.

Figure 2 shows in greater detail the shape of the protrusion 12 and in particular the flow paths of the hot gas flow within the cavity 9 and of the cooling flow through the openings 11' in the heat shielding on the inner casing wall 3. The hot gas flow 10 flows along the channel wall 4' and continues in several

directions after it leaves the trailing edge te_6 of the stationary blade 6. A portion of the hot gas flow continues along the rotating blade shroud 7 as shown by the arrow 20. A further portion of the hot gas flow is diverted from its original direction away from the blade airfoil leading edge le_5 and impinges on the shroud 7 of blade 5 in the vicinity of its leading edge as indicated by the arrow 21.

[0024] A cooling flow 11 such as air or steam enters the cavity 9 via the openings 11' in the heat shielding of the cavity walls 9a and flows into the first, radially outer space 25 of the cavity 9. Due to the delimitation of the space by the protrusion 12, the cooling flow enters a vortex 24 within that space 25. Due to its vortex flow path, its efficiency to cool the cavity walls and shroud 7 in that region is increased. Some of the cooling flow can flow as a leakage flow through the gap between the fin 8 and the cavity wall 9b and reaches into the spaces 9' and 9'' between the downstream fins 8, 8', and 8'' and cool the shroud and inner casing walls within these spaces.

[0025] A further portion 22 of the hot gas flow 10 entering the cavity 9 is diverted into the second, radially inner space 23. The delimitation of the space 23 by the protrusion 12 forces that hot gas flow into a vortex path 22, whereby the passage of a hot gas flow through the gap between the protrusion 12 and the cavity wall 9a and toward the cooling flow 11 is limited. The direction of the hot gas vortex 22 as indicated in the figure furthermore enforces the formation of the cooling fluid vortex 24. Thus, by the given directions of the two vortices as indicated by the arrows in the figure the hot gas flow 22 and the cooling flow 25 remain substantially contained within the spaces 23 and 25, respectively. Thereby, the temperature of the cooling flow remains at a lower level compared to the case when hot gas flows can mix with the cooling flow. Thus, the cooling efficiency of the cooling of the shroud is further improved.

[0026] The protrusion 12 can have a wing-like shape, where the radially inner surface has a curved contour convexly curved toward the turbine's rotor, as shown in the figures. Other shape parameters of the protrusion may be largely determined by manufacturing considerations.

[0027] Figure 3 shows in greater detail the geometry of the protrusion 12 with respect to the walls 9a and 9b of the cavity 9 and its degree of extension into the cavity 9. In one exemplary embodiment of the invention, the protrusion 12 of the shroud 7, when viewed in this meridional cross-section of the gas turbine, is shaped such that a line t_1 tangent to its radially inner surface at its outer tip extends at an angle α with respect to the cross-sectional direction t_2 of the flow channel wall 4'. The angle α can be within a range from 30° to 60°. The radially inner surface of the protrusion 12 between the leading edge of the blade and its tip preferably has a curved smooth shape. This shape provides optimal conditions for the diversion of a hot gas flow reaching into the cavity 9 and

forcing it into a vortex flow in the radially inner space 23 of the cavity 9 in the direction as shown in figure 2.

[0028] In a further embodiment of the invention, the degree of the protrusion 12 into the cavity 9 is given by an angle β between the direction of the flow channel wall 4' and a line of sight t_3 starting from the radial inner most point of the cavity 9 at the trailing edge te_6 of stationary blade and ending at the tip of the protrusion 12. This angle β may be in a range from 10° to 40° and defines the extent of the protrusion into the cavity and the amount of closure of the gap between the tip of the protrusion and the radially extending cavity wall 9a.

[0029] The disclosed ranges for the angles α and β assure the formation of the vortices 22 and 24 in the two cavity spaces 23 and 25 and minimization of the hot gas flow mixing with the cooling flow. Thereby they allow the effective cooling of the shroud and heat shields on the casing walls. Specific angles α and β may be determined within these ranges according to the transient behavior of the gas turbine.

[0030] The choice of the angle α determines the relative sizes of the two cavity spaces 25 and 23 generated by the protrusion 12. The greater the angle α , the smaller the size of the radially outer space 25 and the greater the size of the radial inner space 23 will become. In one embodiment of the invention, the angle α is chosen such that the radial extent h_1 of the radially outer space 24 is at least 25 % of the radial extent h_2 of the radially inner space 24. The distance h_1 is given by the radial distance between the point of the intersection of the tangent line t_1 at the tip of the protrusion 12 with the radially extending cavity wall 9a to the axially extending cavity wall 9b. The distance h_2 is given by the distance between said intersection point at the radial cavity wall 9a and the radially inner most point of the cavity wall 9a, where the wall 9a meets the trailing edge te_6 of the stationary blade 6.

[0031] This 25% minimum radial size of the radially outer space 25 relative to the radial size of the radially inner space of the cavity 9 assures an optimized cooling of the shroud and cavity walls.

[0032] In order to allow a further optimization of the cooling efficiency within the radially outer space 25, the openings 11' for the cooling fluid are positioned in the radially extending cavity wall 9a within the radially outer half of that cavity, that is within the radially outer half of h_1 .

Terms used in Figures

[0033]

- | | |
|---|----------------------------------|
| 1 | gas turbine shaft |
| 2 | rotor axis |
| 3 | gas turbine inner casing, stator |
| 4 | flow channel |

4'	inner casing wall, flow channel wall		ity wall
5, 5'	rotating blades	h_2	radial dimension of radially inner cavity from intersection between tangent line to tip of protrusion with cavity wall to radially innermost point of cavity
6, 6'	stator, stationary blades	5	
7	rotating blade shroud	t_1	line tangent to protrusion at tip of protrusion
8, 8', 8"	fins	10	t_2 direction of flow channel wall 4'
9, 9', 9"	cavities in inner casing	t_3	line from tip of protrusion and radial inner end of the cavity wall
9a	radially extending cavity wall		
9b	axially extending cavity wall	15	
10	hot gas flow		Claims
11	cooling fluid flow		1. Gas turbine comprising a rotor (1) rotatable about a rotor axis (1) and with rotating blades (5, 5') mounted on the rotor (1) in circumferential rows, furthermore comprising a stator with an inner casing (3) and stationary blades (6, 6') mounted in circumferential rows axially adjacent to the rotating blades (5, 5'), where the inner casing (3) and the rotor (1) define a flow channel with a flow channel wall (4'), and where each rotating blade (5, 5') comprises a blade shroud (7) having a fin (8) extending into a circumferentially extending cavity (9) of the inner casing (3), and where the gas turbine comprises a cooling arrangement with openings (11') for a cooling flow (11) arranged in a wall of the circumferentially extending cavity (9) in the inner casing (3)
11'	openings for cooling fluid	20	
12	protrusion on rotating blade shroud		
le ₅	leading edge of blade 5	25	characterized in that
le ₆	leading edge of blade 6		the cooling arrangement comprises a protrusion (12) on the rotating blade shroud (7) extending away from the leading edge (le ₅) of the rotating blade (5) and into the circumferentially extending cavity (9) in the inner casing (3) having the openings (11') for the cooling flow (11), where the protrusion (12) extends in a direction dividing the space of the circumferential cavity (9) into a first, radially outer space (25) and a second, radially inner space (23), where the openings (11') for the cooling flow (11) are arranged within the radially outer space (25).
te ₅	trailing edge of blade 5	30	
te ₆	trailing edge of blade 6		
20	hot gas flow		
21	hot gas flow	35	
22	hot gas flow in vortex		
23	radially inner cavity	40	
24	cooling flow in vortex		
25	radially outer cavity		
26	leakage flow of cooling fluid	45	
α	angle between direction of flow channel wall and line tangent to tip of protrusion		2. Gas turbine according to claim 1
β	angle between direction of flow channel wall and line through tip of protrusion and point where flow channel wall meets radially extending cavity wall at the stationary blade trailing edge	50	characterized in that
h_1	radial dimension of radially outer cavity from intersection between tangent line to tip of protrusion with cavity wall to axially extending cav-	55	a line (t_1) tangent to the radially inner surface of the protrusion (12) at the outer tip of the protrusion (12) of the blade shroud extends at a first angle (α) to the direction (t_2) of the flow channel wall (4') of the gas turbine, where the first angle (α) is in a range from 30 ° to 60°.
			3. Gas turbine according to claim 1
			characterized in that
			the direction (t_2) of the flow channel wall (4') forms a second angle (β) with a line of sight (t_3) extending

from the tip of the protrusion (12) of the shroud of the rotating blade (5) to the radially inner most point of the wall (9a) of the circumferentially extending cavity (9) in the inner casing (3), where the wall (9a) of the cavity (9) meets the trailing edge (te_6) of the stationary blade (6) adjacent to the rotating blade (5), and where the second angle (β) is in the range from 10° to 40° .

4. Gas turbine according to claim 1

characterized in that

the circumferentially extending cavity (9) in the wall of the inner casing (3) comprises a radially extending cavity wall (9a) and an axially extending wall (9b), and a line (t_1), which is tangent to the radially inner surface of the protrusion (12) at the outer tip of the protrusion (12) of the blade shroud (7), intersects the radially extending wall (9a) of the cavity (9) at a point, from where there is a first radial distance (h1) to the axially extending wall (9b) of the cavity (9) and from where there is a second radial distance (h2) to a radially inner most point of the circumferentially extending cavity (9) at the trailing edge (te_6) of a stationary blade (6) adjacent to the rotating blade (5), and where the ratio of the first radial distance (h1) to the second radial distance (h2) is 0.25 or more.

5. Gas turbine according to claim 4

characterized in that

the openings (11') for the cooling medium (11) are arranged in the radially extending wall (9a) of the circumferentially extending cavity (9) in the inner casing within a region of the axially extending wall (9b) of the cavity (9), where this region extends from the axially extending wall (9b) to one half of the first radial distance (h1).

6. Gas turbine according to claim 1

characterized in that

walls (9a, 9b) of the cavity (9) in the inner casing (3) comprise thermal heat shields.

7. Gas turbine according to claim 1

characterized in that

the cooling flow (11) entering into the circumferentially extending cavity (9) of the inner casing (3) follows a vortex path (24) in the first, radially outer space (25) and a hot gas flow (10) entering into the circumferentially extending cavity (9) of the inner casing (3) follows vortex flow (22) in the second, radially inner space (23).

8. Gas turbine according to claim 7

characterized in that

the cooling flow following the vortex (24) in the first, radially outer space (25) is in a direction, where starting from the openings (11') in the cavity wall (9a), it first is in the downstream direction relative to the di-

rection of the main flow (10) in the flow channel (4), then radially inward, then in the upstream direction, then radially outward, and then again in the downstream direction,

and where the cooling flow following the vortex (22) in the second, radially inner space (23) is in a direction, where starting at the leading edge (le_5) of the rotating blade (5), it is first in a radially outward direction, followed by an upstream direction relative to the direction of the gas flow (10) in the flow channel (4), then in a radially inward direction, then in a downstream direction, then again in the radially outward direction.

Amended claims in accordance with Rule 137(2) EPC.

1. Gas turbine comprising a rotor (1) rotatable about a rotor axis (2) and with rotating blades (5) mounted on the rotor (1) in a circumferential rows, furthermore comprising a stator with an inner casing (3) and stationary blades (6, 6') mounted in circumferential rows axially adjacent to the rotating blades (5), where the inner casing (3) and the rotor (1) define a flow channel with a flow channel wall (4'), and where each rotating blade (5) comprises a blade shroud (7) having a fin (8) extending into a circumferentially extending cavity (9) of the inner casing (3), and where the gas turbine comprises a cooling arrangement with openings (11') for a cooling flow (11) arranged in a wall of the circumferentially extending cavity (9) in the inner casing (3)

the cooling arrangement comprises a protrusion (12) on the rotating blade shroud (7) extending away from the leading edge (le_5) of the rotating blade (5) and into the circumferentially extending cavity (9) in the inner casing (3) having the openings (11') for the cooling flow (11), where the protrusion (12) extends in a direction dividing the space of the circumferential cavity (9) into a first, radially outer space (25) and a second, radially inner space (23), where the openings (11') for the cooling flow (11) are arranged within the radially outer space (25)

and the circumferentially extending cavity (9) in the wall of the inner casing (3) comprises a radially extending cavity wall (9a) and an axially extending wall (9b),

and a line (t_1), which is tangent to the radially inner surface of the protrusion (12) at the outer tip of the protrusion (12) of the blade shroud (7), intersects the radially extending wall (9a) of the cavity (9) at a point, from where there is a first radial distance (h1) to the axially extending wall (9b) of the cavity (9) and from where there is a second radial distance (h2) to a radially inner most point of the circumferentially extending cavity (9) at the trailing edge (te_6) of a stationary blade (6) adjacent to the rotating blade (5),

and where the ratio of the first radial distance (h_1) to the second radial distance (h_2) is 0.25 or more.

2. Gas turbine according to claim 1

characterized in that

the openings (11') for the cooling medium (11) are arranged in the radially extending wall (9a) of the circumferentially extending cavity (9) in the inner casing within a region of the axially extending wall (9b) of the cavity (9), where this region extends from the axially extending wall (9b) to one half of the first radial distance (h_1).

3. Gas turbine according to claim 1 or 2

characterized in that

a line (t_1) tangent to the radially inner surface of the protrusion (12) at the outer tip of the protrusion (12) of the blade shroud extends at a first angle (α) to the direction (t_2) of the flow channel wall (4') of the gas turbine

where the direction (t_2) of the flow channel (4') of the gas turbine is defined to extend tangentially to the radially inner contour line of the blade shroud (7) and to a point at the casing wall (4) and at the trailing edge (te_6) of the vane (6) upstream of the blade (5), and where said first angle (α) is in a range from 30° to 60°.

4. Gas turbine according to claim 3

characterized in that

the direction (t_2) of the flow channel wall (4') forms a second angle (β) with a line of sight (t_3) extending from the tip of the protrusion (12) of the shroud of the rotating blade (5) to the radially inner most point of the wall (9a) of the circumferentially extending cavity (9) in the inner casing (3), where the wall (9a) of the cavity (9) meets the trailing edge (te_6) of the stationary blade (6) adjacent to the rotating blade (5), and where the second angle (β) is in the range from 10° to 40°.

5. Gas turbine according to claim 1 or 2

characterized in that

walls (9a, 9b) of the cavity (9) in the inner casing (3) comprise thermal heat shields.

6. Gas turbine according to claim 1 or 2

characterized in that

the cooling flow (11) entering into the circumferentially extending cavity (9) of the inner casing (3) follows a vortex path (24) in the first, radially outer space (25) and a hot gas flow (10) entering into the circumferentially extending cavity (9) of the inner casing (3) follows vortex flow (22) in the second, radially inner space (23).

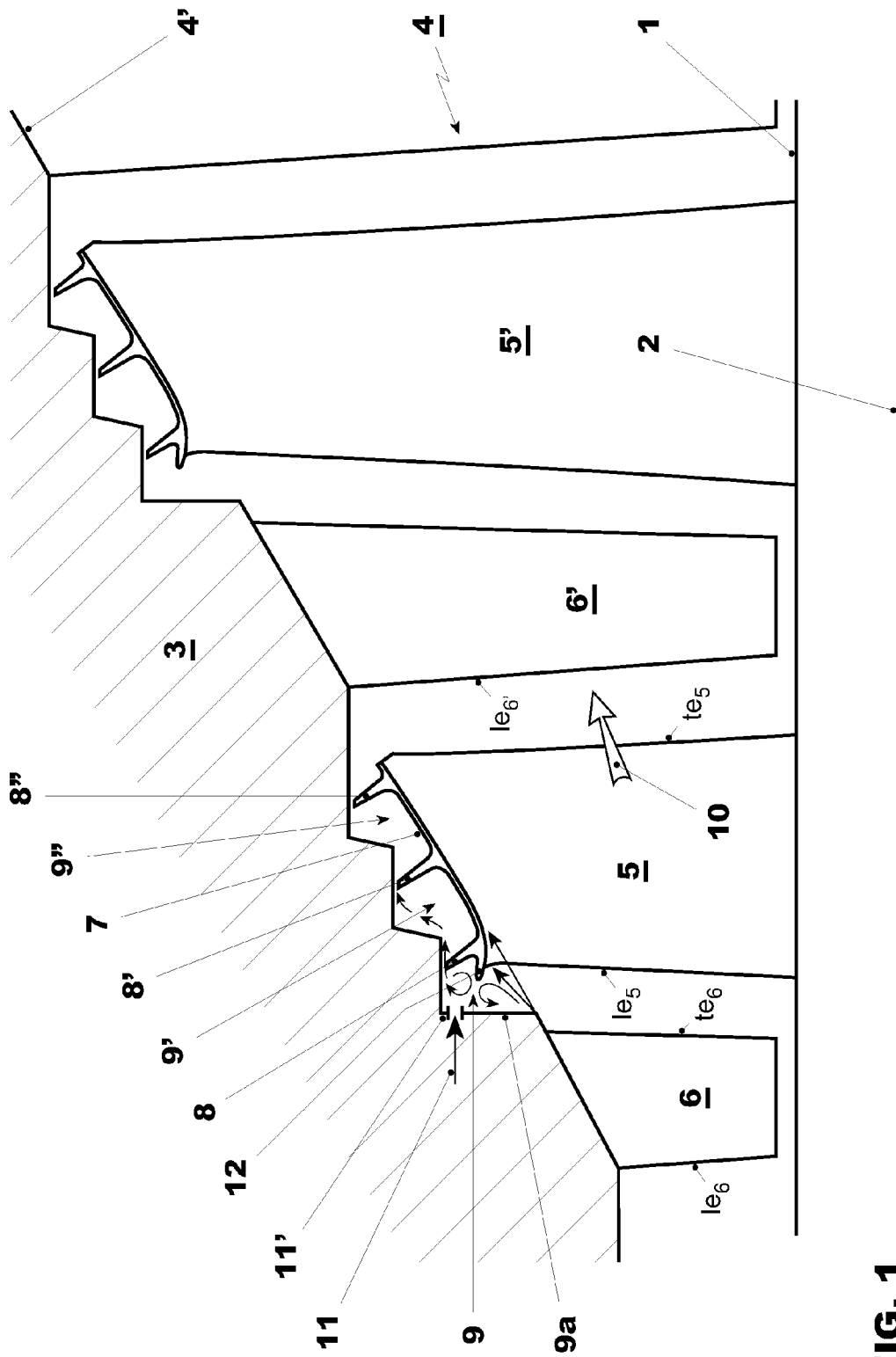


FIG. 1

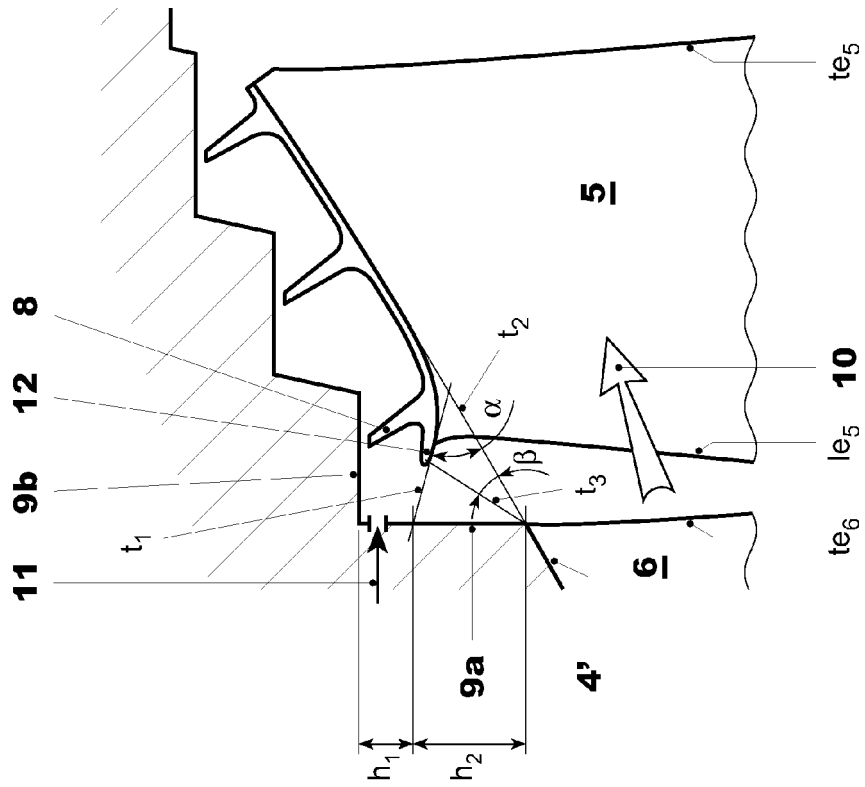


FIG. 3

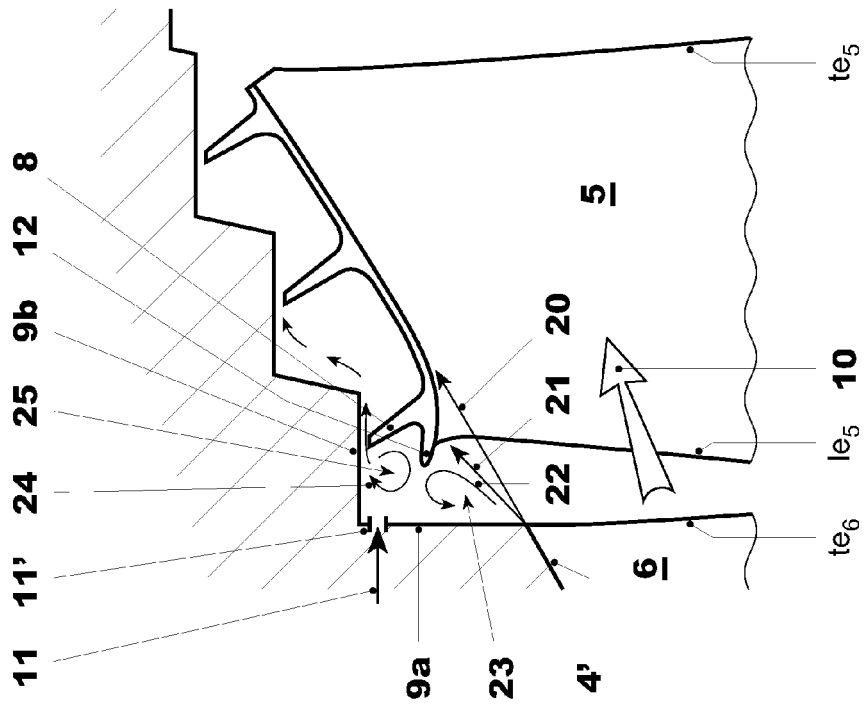


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 10 16 4084

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